UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
BERKELEY, CALIFORNIA

AGRICULTURAL EXPERIMENT STATION
E. J. WICKSON, ACTING DIRECTOR

CIRCULAR No. 30

(JUNE, 1907.)

WHITE FLY IN CALIFORNIA

BY C. W. WOODWORTH.

The white fly has at last become established in California. The most destructive insect in the citrus groves of Florida is this species of white fly, the *Aleurodes citri*. It is considered by the growers there as much more injurious than any of the scale insects attacking these fruits. Our trees were supposed to be free from the pest, but now

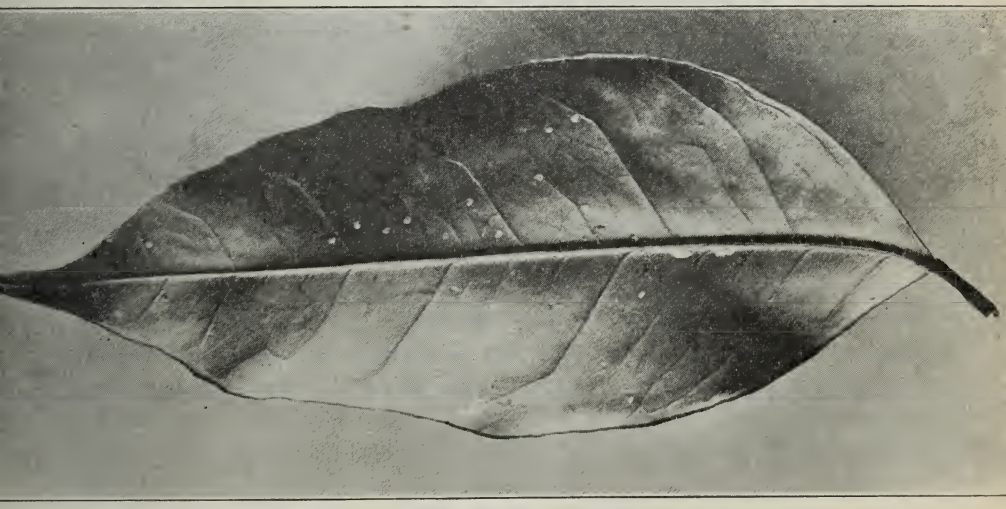

Figure 1.—The white fly on a leaf. Natural size.

a well established colony has made its appearance at Marysville at a center of travel by both steam and electric railways where the conditions seem particularly favorable to its spread over the State.

The seriousness of these facts to the citrus industry of this State renders it imperative that full publicity be given them in order that

the proper steps may be taken to meet this emergency. We are not sure that the insect is confined to this one locality. Every one who has trees should carefully inspect them and submit all suspicious specimens to some one capable of accurately identifying them. The Experiment Station will be glad to examine and report on any that may be submitted for this purpose. It may be entirely possible to eradicate an insect before it has become well established, but it will if allowed to increase become too widely distributed to effectively handle.

Many have been very apprehensive of the danger of introducing this insect from Florida and have been instrumental in having most stringent laws enacted preventing the importation of anything from that State liable to be infested, while others have maintained that the insect could not live in this climate at all. In support of this idea it has been claimed that the insect must have been introduced into the State many times on nursery stock before these laws went into effect and since that time on plants that escaped the attention of the inspectors. Many other species of white flies are able to live in California, however, including at least one injurious species. We do not have to speculate any longer on this matter since the insect in question is now not only existing here but thriving. Moreover, the insect is not appearing in the most humid parts of the State, but in the interior where the black scale is unable to thrive, that is, in a climate comparable to Riverside.

Though we now know that the white fly does live and thrive in our climate in the city of Marysville, there are those who still believe that our orchards are not menaced, still arguing on the basis of the climatic differences between California and Florida. The red scale, the black scale, and the purple scale are all Florida insects and have not found our climate impossible. Possibly the white fly may prove to be different, but it does not seem the part of wisdom to permit the white fly to have free access to our citrus orchards on the chance that it may not thrive there.

LIFE HISTORY.

The white fly must have been in California at least a full year judging by its distribution and abundance at Marysville, but no observations have been made on its life history and habits except during the last few weeks since its discovery in the State. There is but little doubt, however, that it will prove to be much the same as in Florida. The most elaborate study of this insect is that reported in Bulletin 67

of the Florida Experiment Station by Professor H. A. Gossard. In the following account of the insect much will be taken from this publication including the two plates illustrating the structure of the insect.

The Egg.—At the present time the insect is chiefly in the egg stage. These are shown very much enlarged in figure 2, which was photographed from a specimen collected at Marysville, and illustrates how

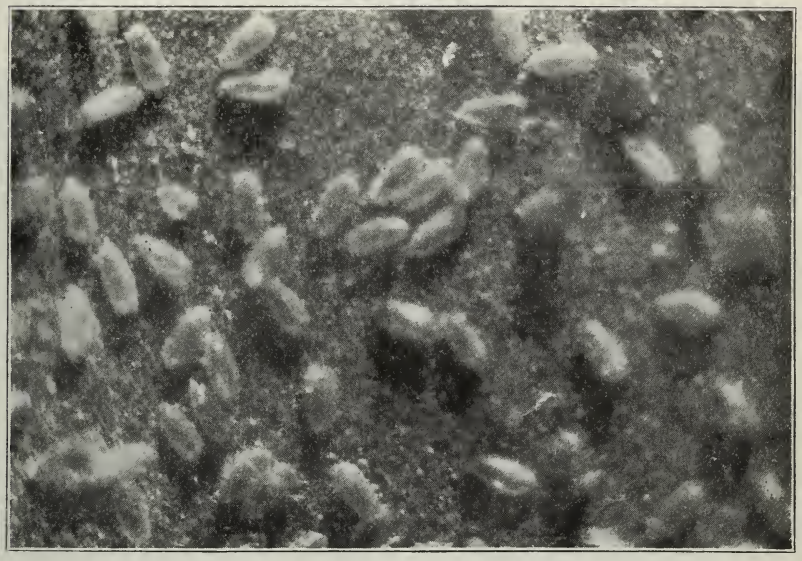

Figure 2.—Eggs of the white fly.

numerous they become. There were many thousands of such eggs on this leaf. Nearly every leaf on the trees in that part of town was similarly infested. These eggs are so small as to be scarcely visible to the eye singly, but the badly infested leaves appeared as though covered with mold. While rather less than half of the town of Marysville is badly infested, still a careful examination would show the presence of a few eggs on nearly every tree in town.

The eggs of the white flies are all very much alike and can be at once distinguished from every other known group of insects. The shape of the egg and of the stalk at the end by which it is attached to the leaf are sufficient to distinguish them. It is not, however, easy to distinguish between the eggs of the different species of white flies.

The presence of an egg of this character on the leaf of an orange or lemon is quite conclusive evidence of the presence of the destructive white fly of Florida.

According to Gossard, the egg requires from three to twenty days to hatch, according to the weather. In the hatching process the egg-shell splits in the manner shown in plate 1, figure 4.

The Nymph.—The young insect on hatching very much resembles a young scale insect, but can be readily distinguished by comparing a

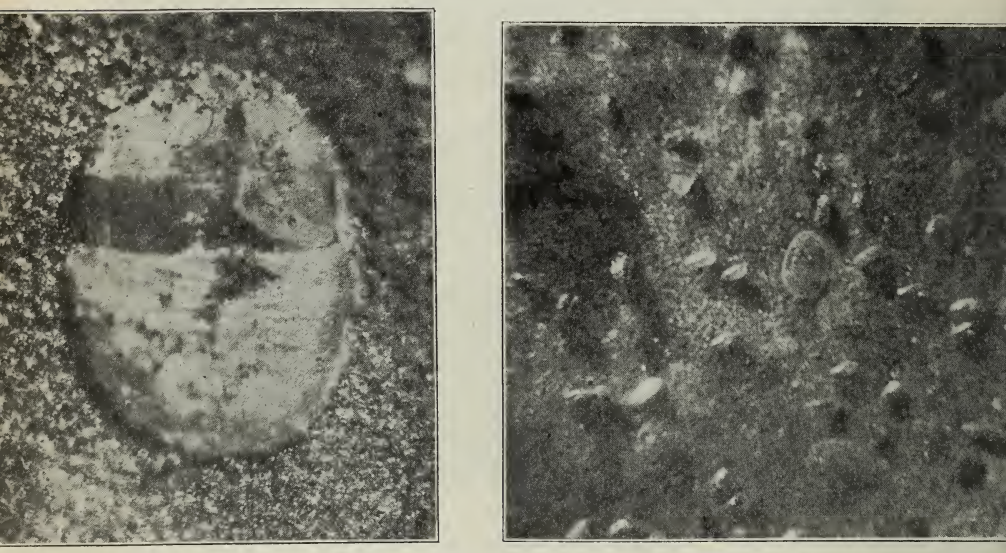

Figure 3.—Exuvium of the white fly and a young nymph.

carefully mounted specimen under a medium or high power of the microscope with the figure shown on plate 2, figure 1. Like the scale insects, the young white fly wanders over the twigs and leaves for a few hours, finally attaching itself by inserting its mouthparts into the leaf. After thus locating itself the young insect soon secretes a wax in sufficient quantity to fill the space between the body and the leaf. Because of the small size and transparency of the body and this cementing of the body to the leaf the insect is almost invisible. This makes it rather difficult to secure a good photograph of the insect. Figure 3 illustrates a partly grown nymph collected at Marysville produced from eggs laid this spring by flies appearing before the great majority had emerged.

In structure and habits the nymph is so like scale insects that if seen at all they could easily pass as young scales. It is not safe indeed to depend on the use of a hand magnifier for the identification of a young or partly grown nymph until one is thoroughly familiar with them, and even then the use of a compound microscope should be resorted to. The details of structure shown by a properly mounted microscopical preparation of the various stages is well shown on plate 2.

Figure 4.—White fly exuviae on leaf, much enlarged.

Within the body of the nymph during the last stage wings are developed in both sexes and the whole internal structure reorganized so that when the skin is finally cast off a slender bodied, delicate fly emerges. This is in striking contrast to the life history of scale insects where the male alone obtains wings. This makes the problem of the control of this insect entirely different and much more difficult than that of scale insects, as will be shown in the discussion of this subject below.

The full grown nymphs have a very much thicker skin than the younger stages and this remains attached to the leaf after the molt. This dried skin is very much more conspicuous than the living insect

and is the form illustrated in figures 1, 3, 4, 5, and 6. On some trees at Marysville most of the old leaves are well spotted over on the under side of these exuviae, as shown in figure 5.

The Adult Insect.—The name white fly was given to the insects of this class on account of the appearance of the adult insect. Its snowy white color makes the insect very conspicuous notwithstanding its extremely small size. In the spring they appear in great numbers for two or three weeks and then suddenly disappear after laying their

Figure 5.—Leaf showing dirty condition when badly infested.

eggs, only a very few belated individuals coming out after the others remaining in the trees. In mid-summer a second brood begins to appear. There is no distinct swarm as in the spring, but during the whole latter half of the year the adult white fly can be seen on the trees in greater or less abundance. After the colder weather of winter begins the adults almost entirely disappear and are not seen again until the spring emergence. The life of any individual fly is very brief, averaging, according to Gossard, between four days and a week. During this time the eggs are laid, and as many as seventy-five have been deposited by a single female.

EXPLANATION OF PLATE I.

Aleyrodes citri.

(This plate is reproduced from Bulletin No. 67 of the Florida Agricultural Experiment Station.)

Fig. 1.—Adult female, with expanded wings, much enlarged.

Fig. 2.—Adult female, with wings folded over the body in normal roof-like position.

Fig. 3.—Egg and foot-stalk of same, greatly magnified.

Fig. 4.—Egg-shell, showing the split through which the larva emerged.

Fig. 5.—Tip of male abdomen, showing claspers.

Fig. 6.—Antenna, showing annulated joints.

Fig. 7.—Fore margin of front wing.

Insects sometimes mistaken for *A. citri:*

Fig. 8.—Larva of *Aleyrodes floridensis,* greatly magnified.

Fig. 10.—Greatly enlarged section of waxen fringe, surrounding *A. floridensis.*

Fig. 11.—Outline of larva of *Lecanium hesperidum.*

EXPLANATION OF PLATE II.

(This plate is reproduced from Bulletin No. 67 of the Florida Agricultural Experiment Station.)

Aleyrodes citri.

Fig. 1.—Larva, first stage, greatly magnified.

Fig. 2.—Larva, first stage, drawn to same scale as figures 3, 4, 5, 8, 9, and 10.

Fig. 3.—Larva, second stage.

Fig. 4.—Larva, third stage.

Fig. 5.—Larva, fourth stage.

Fig. 6.—Margin of advanced larva, greatly enlarged.

Fig. 7.—Vasiform orifice of fourth larval stage, showing crenulated operculum with ligula in the center.

Fig. 8.—Pupa, showing embryo and distribution of orange-colored areas. Waxen tufts extending from the breathing tubes are shown.

Fig. 9.—Adult, with folded wings, emerging from the pupa case.

Fig. 10.—Empty pupa case, showing split through which the fly emerged.

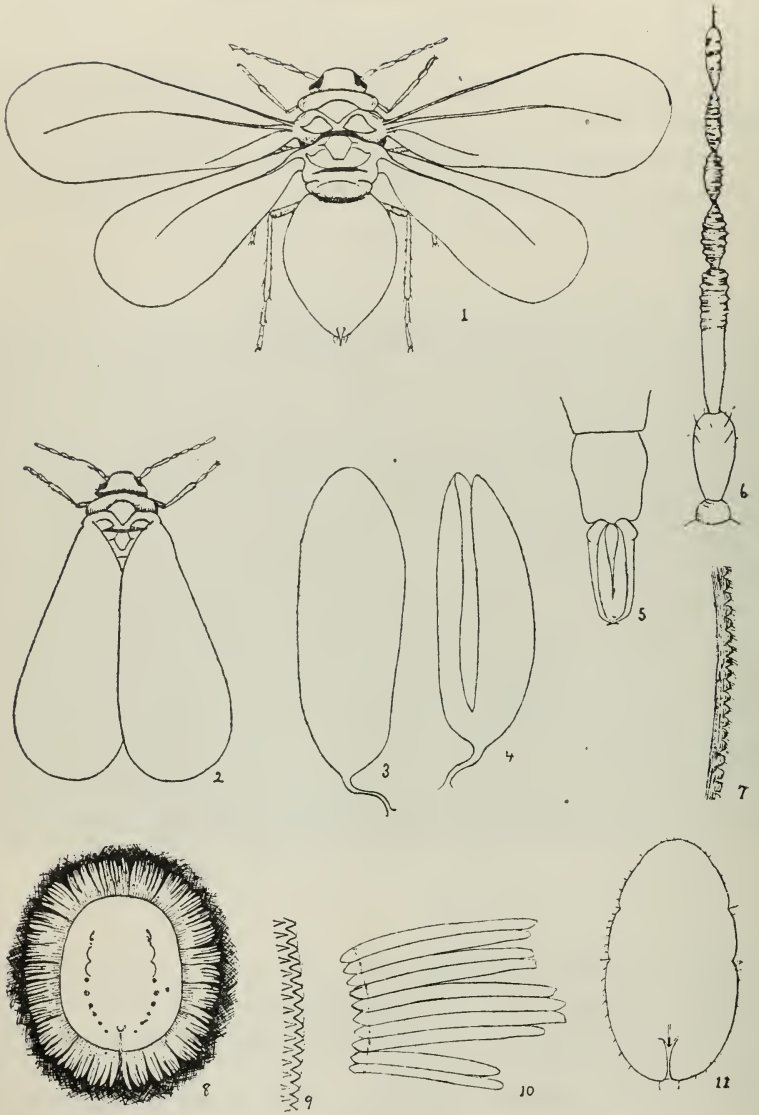

PLATE I.

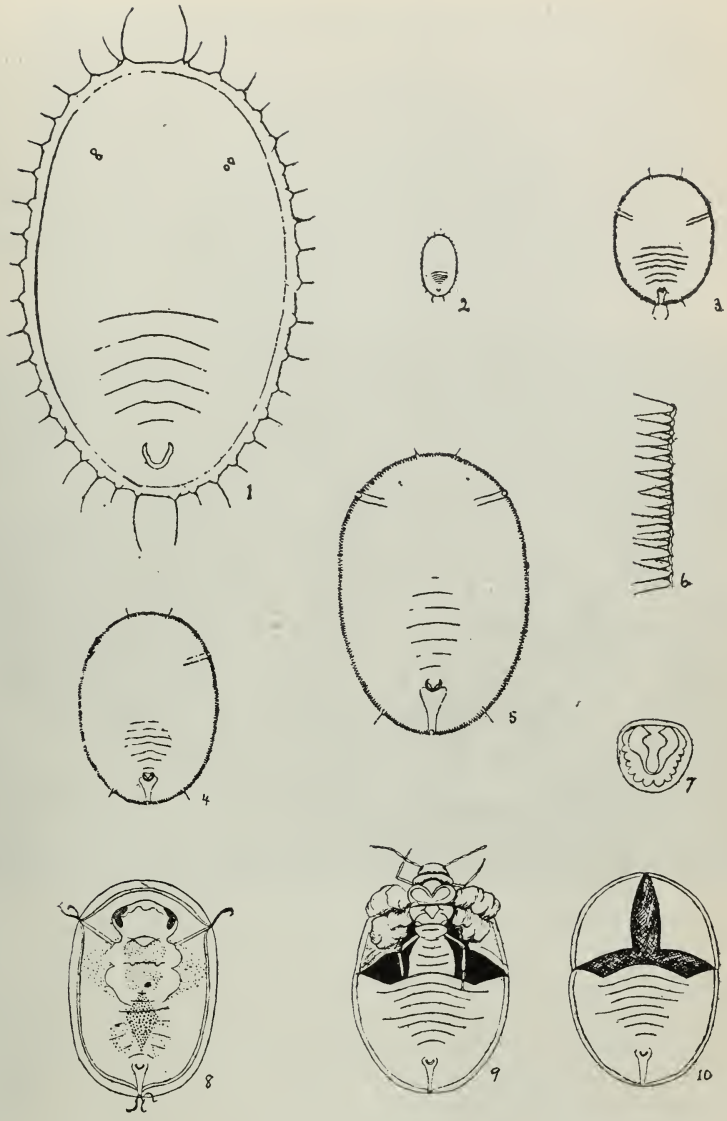

PLATE II.

THE DETECTION OF THE WHITE FLY.

At the present time the discovery of the presence of the white fly is of very great importance. After the insect has become so numerous that it is conspicuous either by its injuries or the swarms of the adult it is doubtful if eradication is possible, at least without very radical measures being employed. Much misapprehension can be avoided by getting a correct idea of the insect and of the things it is liable to be confounded with.

Figure 6.—Red scale, adult and young, and exuviae of white fly.

First it should be understood that the white fly is very minute. There is no other insect pest on citrus trees as small as the white fly, unless it be small individuals of the red or yellow scale. Figure 6 shows these two insects on the same leaf, and will give some idea of their relative appearance. The lighter spots are the exuviae of the white fly. There were a few young and eggs of this insect, but they could not be shown without magnification. The small dark spots are the young of the red scale. The structure of the scale is better shown in figure 7. The red or yellow scale occurs on the upper side of the leaf as well as below (see figure 8) and sometimes on twigs and fruit,

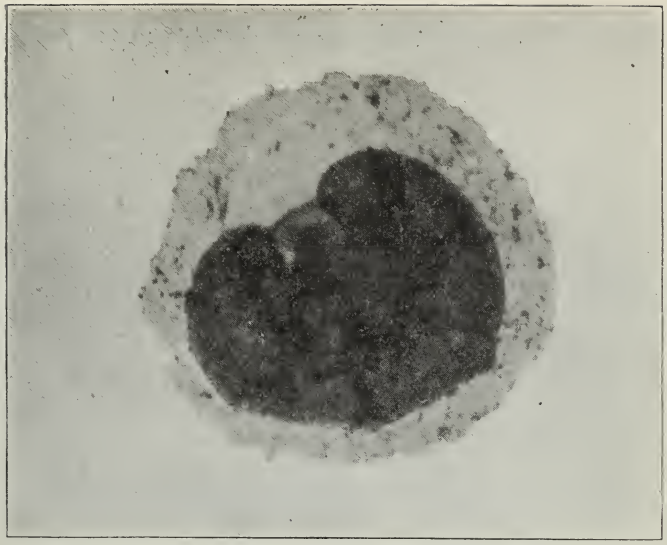

Figure 7.—Red scale, much magnified.

while the white fly confines itself exclusively to the leaves and almost exclusively to the under side of the leaves. No one will, however, confound these two insects if they see them clearly, for they are so

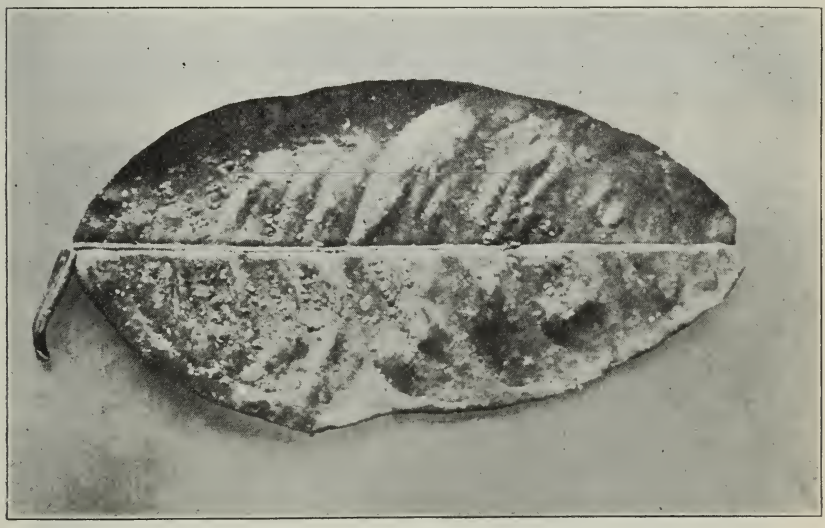

Figure 8.—Red scale on upper side of leaf.

Figure 9.—Red scale on leaf, much enlarged.

totally different in appearance. The comparison of figures 4 and 9 will show the differences that can be brought out by a hand magnifier between the exuvium of a white fly and the adult red scale, which might be confounded at first glance without the lens.

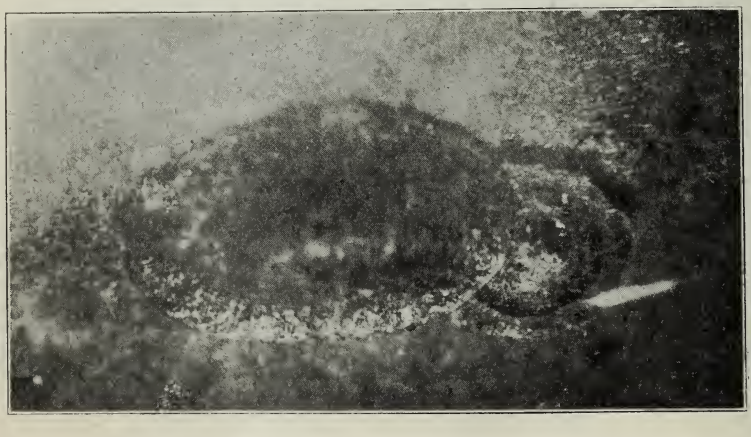

Figure 10.—Red and soft brown scale, much enlarged.

An insect much more likely to be confused with the white fly is the soft brown scale. This is a much larger insect than either the red scale or the white fly. Figure 10 shows about the smallest size of the adult; it is often more than twice as long. One can very easily mistake, however, a very young soft brown scale for a partly or fully grown nymph of the white fly. The soft brown scale is rarely as transparent as a white fly of the same size and is therefore much more easily seen. If one bends a leaf just beneath a young white fly he can generally succeed in causing the waxy cement that holds the insect to the leaf to

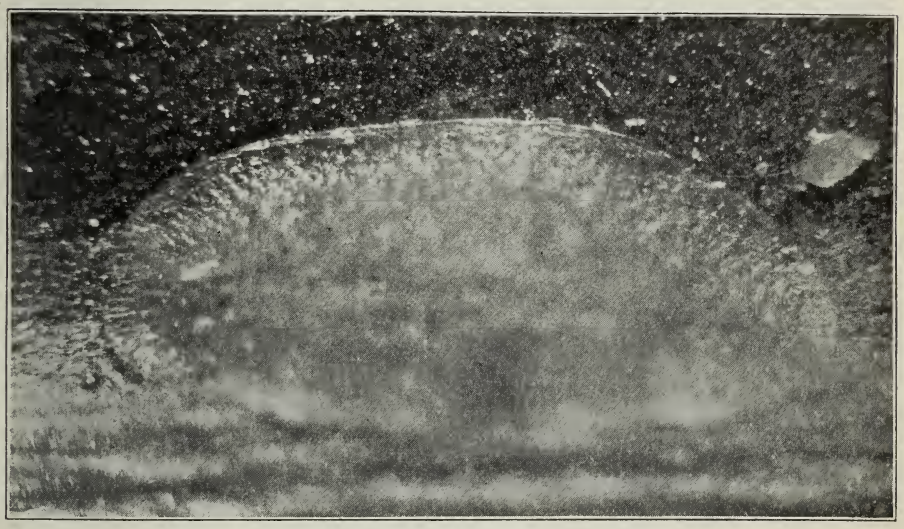

Figure 11.—The soft brown scale, much enlarged.

separate, allowing air to go beneath the insect, making it much more plainly visible, while no kind of manipulation produces such an effect on the soft brown scale. There will be many doubtful cases, however, where the compound microscope needs to be brought into use. When this is done a comparison with figure 11 of plate I and figures 1 to 8 of plate II will enable one to answer the question with absolute certainty.

There are many kinds of spots to be found on orange leaves which will be viewed with suspicion, all of which can be readily distinguished by the use of a good hand lens. We will figure only one of these, the nature of which is not generally understood. The small, active, dark

colored insects so common on orange trees, belonging to the family *Psocidae,* spin a small white silken covering for their eggs, as shown in figure 12. The white fly exists on the tree only in four forms: the egg, the nymph, the old finally discarded skin of the full grown nymph called the exuvium, and the active flying stage of the adult insect. All of these are illustrated in this circular. Any other kind of spot or structure on the leaf is certainly something else than the white fly.

Figure 12.—Egg cocoon of a Psocid.

The means of distinguishing this species of white fly from other members of the same family is a rather difficult and complicated matter, but can be done by a careful comparison of the minuter details shown in plate II, especially in figures 5 and 8.

FOOD PLANTS.

The white fly seems to prefer the leaves of orange and lemon, but will come to maturity on quite a variety of plants. This greatly complicates the problem of their eradication or control. The following is a list of the plants upon which the insect breeds in Florida, as recorded by Gossard.

Citrus, all species.
China berry tree (*Melia azederach*).
Viburnum nudum.
Cape jessamine (*Gardenia florida*).
Japan persimmon (*Diospyros kaki*).
California privet (*Ligustrum amurense*).
Golden privet (*Ligustrum* sp.) .
Mock orange (*Prunus caroliniana*).
Ficus, various species.
Water oak (*Quercus aquatica*).
Prickly ash (*Xanthoxylum* sp.).

CHARACTER OF INJURY.

The injury done by the white fly is of exactly the same character as that done by scale insects, with the exception that being confined to the leaves there is no direct damage to the twigs and larger branches that makes the work of the San José scale, for instance, so fatal to the trees it attacks. Its direct effect on the foliage is similar to that of the red or purple scale and its indirect effect like that of the black scale. Doubtless this latter will be considered the more serious since the excretions of this insect seem to cause the smut to cling with so much tenacity that it is practically impossible to remove it.

METHODS OF CONTROL.

We have of course no experience in California in the control of this insect. The best Florida practice as recommended by Professor Gossard is as follows:

December—Spray with resin soap.
January—Spray with resin soap.
February—Spray again as above if necessary.
June—Spray with potash whale oil soap.
July—Spray with potash soap and sulfur.
August—Spray with potash soap and sulfur.
September—Spray with potash soap and sulfur.

Such a programme of spraying would seem rather hard to carry out to our growers, and possibly we might find that two or three fumigations a year would be as effective as the larger number of sprayings, or perhaps one fumigation followed by several summer sprayings. Our trees are mostly low and small as compared with the Florida groves, so that fumigation is possible as it would not be in that State.

None of the scale insects can fly, and therefore distribute themselves very slowly; but with the white fly in a community a clean orchard may become badly infested in a day, making summer treatment necessary no matter how thorough the winter work has been.

THE PRESENT PROBLEM IN CALIFORNIA.

As far as is known the white fly is still confined to the city limits of Marysville. There are no citrus orchards in the immediate neighborhood. Possibly therefore it may not have reached any other section. If let alone it certainly will reach every part of the State. The trees in the immediate neighborhood of the railroad tracks are now infested. The electric cars pass between infested trees going to the orange orchards of Butte county. Now, if ever, is the time to make an effort to destroy the pest. There is no possibility of throwing a quarantine around the infested district that a flying insect will respect. To delay all effort towards eradication till next winter, as seems now to be the programme, may be a fatal error. Every day during the latter part of the summer thousands if not hundreds of thousands of these minute creatures will be in the air capable of living long enough to be carried, in a car, the length of the State. A single one of these reaching a citrus district might make the eradication of the insect an impossibility. It may be that already the insect has gotten beyond control, but the chance of eradication is certainly worth the effort.

If eradication is to be attempted no half-way measures like spraying or fumigation are to be thought of. There is too much opportunity to miss some and no ready means of discovering the fact. A campaign of eradication should include: first, the immediate destruction of every leaf on all citrus trees in Marysville and of every other plant known to furnish sustenance to this insect; second, a thorough inspection of the new foliage as it comes out on the defoliated plants; third, an exhaustive search for other possible food plants of the white fly; fourth, redefoliation and persistent reinspection of any spots where the fly may not have been annihilated; fifth, careful inspection of every supposed case of white fly in the State; and finally competent scientific supervision of the work.

There will be very few adult flies produced during this month and the early part of July. After that the problem will be much greater and the chances of success correspondingly lessened. Will those most vitally interested see that the work is undertaken?